APPLICATION FOR UNITED STATES LETTERS PATENT

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for

CONNECTOR PROVIDING CAPACITIVE COUPLING

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CONNECTOR PROVIDING CAPACITIVE COUPLING

BACKGROUND OF THE INVENTION

[1] It is often necessary to distribute high-speed signals, such as high-speed differential signals, from one circuit device, such as an integrated circuit or printed circuitboard, to another such circuit device. This may require capacitive or "AC" coupling.

[2] Typically, high-speed signals requiring such AC coupling are routed within internal layers of multi-layered substrates of printed circuitboards or integrated circuits, as known in the art. To provide AC-coupling, coupling or blocking capacitors are used which are mounted on the circuit device substrates (printed circuitboard). To permit the high-speed signals access to the AC blocking capacitors, the signals must be brought to the surface layers of the circuit devices through vias. These vias can have a significant deleterious effect on the signal quality and integrity, especially for high-speed signals having frequencies in the multiple gigabit range. In addition, the adverse signal quality effects increase as the circuit device substrate thickness increases.

[3] Unless preventative measures are taken, the problem will only worsen. As signal rate increases, signal energy content increases, and signal frequency increases, the adverse effects of the vias will prove even more difficult to deal with.

[4] Previous solutions have included ignoring the problem and living with the detrimental effects caused by the vias. Another solution has been to use blind or buried vias where the vias only extend partially through the circuit device substrates. Unfortunately, this increases manufacturing costs of the circuit devices. Another solution has been to back drill the vias to remove unused portions of the vias. This also results in increased manufacturing costs.

[5] The present invention provides a solution to the above-noted problems. As will be seen subsequently, the present invention permits signals to be distributed from one circuit device to another while negating the need for the previously employed vias for accessing surface mounted AC blocking capacitors.

SUMMARY OF THE INVENTION

[6] In one embodiment of the invention, a connector includes a first contact that contacts a conductor of a first circuit, a second contact that contacts a conductor of a second circuit, and a capacitor coupled between the first and second contacts. As a result, the connector capacitively couples the conductor of the first circuit to the conductor of the second circuit.

[7] In various embodiments, the connector may further include an electrically insulative body encapsulating the capacitor and carrying the first and second contacts. One of the first and second contacts may be a male contact or a female contact.

[8] In accordance with further aspects of the invention, the first and second contacts may be disposed along a substantially common line or substantially transverse to each other.

[9] In accordance with a further embodiment, the connector may include a plurality of first contacts, a like plurality of second contacts, and a like plurality of capacitors with each capacitor coupled between a different respective pair of the first and second contacts. The plurality of first contacts and the plurality of second contacts may lie in a substantially common plane. The connector may further include a plurality of contact sets of the plurality of first and second contacts lying in a substantially common plane. The plural contact sets may be disposed substantially parallel to each other.

[10] In accordance with the present invention, first and second device circuits may be capacitively coupled together without requiring vias for accessing AC blocking capacitors. One of the first and second circuits may be an integrated circuit or a printed circuitboard.

[11] These and various other features as well as advantages of the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[12] **FIG. 1** is a generally schematic representation of a connector that embodies the present invention and capacitively connects conductors of a first circuit device to conductors or a second circuit device;

[13] **FIG. 2** illustrates a prospective view of first and second printed circuitboards to be capacitively interconnected by a connector embodiment of the present invention;

[14] **FIG. 3** is a cross-sectional side view of one embodiment of the present invention wherein a connector includes contacts disposed substantially transverse to one another with an AC coupling capacitor coupled between the connector contacts;

[15] **FIG. 4** is a cross-sectional side view of a further embodiment of the present invention wherein a connector includes a male contact and a female contact coupled together by an AC blocking capacitor and wherein the contacts are disposed along substantially common line;

[16] **FIG. 5** is a cross-sectional side view of a still further embodiment of the present invention wherein a connector includes a plurality of contact pairs each pair being coupled together by an AC blocking capacitor and wherein all of the contacts lie within a substantially common plane; and

[17] **FIG. 6** is a perspective view of a still further embodiment of the present invention illustrating how a connector may be modularly constructed in accordance with further aspects of the present invention.

DESCRIPTION OF THE INVENTION

[18] In the following detailed description of an exemplary embodiment of the invention, reference is made to the accompanying drawings, which form a part hereof. The detailed description and drawings illustrates specific exemplary embodiments by which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. It is understood that other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the present invention. The

following detailed description is therefore not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

[19] **FIG. 1** schematically illustrates a first embodiment of the present invention. Here, a connector ***10***, embodying the present invention, capacitively couples conductors of a first circuit device ***12*** to conductors of a second circuit device ***14***. The first circuit device ***12*** includes a differential signal driver ***16*** of the type which generates a high-speed differential signal output on conductors ***18*** and ***20***. The conductors ***18*** and ***20*** are coupled to female contacts ***22*** and ***24*** respectively, which are carried by the circuit device ***12***.

[20] Similarly, the second circuit device ***14*** includes a second differential signal driver ***30*** of the type which may receive the high-speed differential signals provided by the first differential signal driver ***16***. The differential signal driver ***30*** receives the differential signals over conductors ***32*** and ***34*** which are coupled to female contacts ***36*** and ***38*** respectively, carried by the circuit device ***14***.

[21] The connector ***10*** capacitively couples the female contact ***22*** of the first circuit device ***12*** to the female contact ***36*** of the second circuit device ***14*** and the female contact ***24*** of the first circuit device ***12*** to the female contact ***38*** of the second circuit device ***14***. The connector ***10*** includes a first pair of male contacts ***40*** and ***42*** and a second pair of male contacts ***44*** and ***46***. Contacts ***40*** and ***42*** are arranged to be connectively received by the female contacts ***22*** and ***24***. Similarly, the contacts ***44*** and ***46*** are arrangement to be connectively received by the female contacts ***36*** and ***38***. The connector ***10*** further includes AC blocking capacitors ***50*** and ***52***. The capacitor ***50*** is coupled between contact ***40*** and contact ***44*** and the capacitor ***52*** is coupled between the contact ***42*** and the contact ***46***.

[22] As a result of the foregoing, when the contacts ***40*** and ***42*** are received by contacts ***18*** and ***24***, and contacts ***44*** and ***46*** are received by contacts ***36*** and ***38***, the connector ***10*** capacitively couples conductors ***18*** and ***20*** of the first circuit device ***12*** to conductors ***32*** and ***34*** respectively of the second circuit device ***44***. The connector ***10*** further includes a body ***56*** of electrically insulative material in which the capacitors ***50*** and ***52*** are imbedded and which carries the contacts ***40***, ***42***, ***44***,

and ***46***. The body ***56*** may be formed by injection molding or in any other manner known in the art.

[23] Referring now to **FIG. 2**, it illustrates another embodiment of the invention where a first printed circuitboard ***60*** is capacitively coupled to a second printed circuitboard ***62***. The first printed circuitboard ***60*** includes a connector ***64*** embodying the present invention. The connector ***64*** includes a plurality of male contacts ***66***.

[24] The second printed circuitboard ***62*** also includes a connector ***70*** which may embody the present invention. The connector ***70*** includes a plurality of female contacts ***72*** which are arranged to connectively receive the contacts ***66*** carried by the connector ***64***.

[25] **FIG. 3** shows that the connector ***64*** may further include a further plurality of male contacts ***68*** which are arranged substantially transverse to the contacts ***66***. Coupled between the contacts ***66*** and ***68*** is an AC blocking capacitor ***63*** which may capacitively couple a conductor on printed circuitboard ***60*** to a conductor on printed circuitboard ***62***.

[26] Lastly, it will be noted in **FIG. 3** that the connector ***64*** includes a body ***65***. The body ***65*** is preferably formed of an electrically insulative material for carrying the contacts ***66*** and ***68*** and imbedding the capacitor ***63***. To that end, the body ***65*** may be formed by injection molding or many other molding methods known in the art.

[27] **FIG. 4** illustrates a form in which the connector ***70*** may take to embody the present invention. Here, one female contact ***72*** of the plurality of female contacts is illustrated disposed substantially in line with a corresponding male contact ***73***. Although not illustrated, the connector ***70*** may include a male contact for each female contact ***72***. An AC blocking capacitor ***75*** couples the female contact ***72*** to the male contact ***73***. The connector ***70*** further includes a body ***76*** which is molded to encapsulate the capacitor ***75*** and carry the contacts ***72*** and ***73***.

[28] In order to provide capacitive coupling between a conductor of printed circuitboard ***60*** and a conductor of printed circuitboard ***62***, only one of the

connectors ***64*** and ***70*** need incorporate an AC blocking capacitor. Hence, if connector ***64*** includes the capacitor ***63***, then connector ***70*** need not include capacitor ***75*** and the contact ***72*** may be directly coupled to the contact ***73*** without an intervening AC blocking capacitor. Similarly, if the connector ***70*** is to provide the capacitive coupling with capacitor ***75***, then connector ***64*** need not include capacitor ***63***. In this case, contact ***68*** would be coupled directly to contact ***66*** without an intervening capacitor ***63***.

[29] **FIG. 5** illustrates a further embodiment of the present invention. Here, a connector ***80*** is shown in cross-section. The connector ***80*** includes a plurality of first contacts ***82*** and a plurality of second contacts ***84***. Coupling each respective first contact with a respective second contact is an AC blocking capacitor ***86***. In accordance with this embodiment, the first contacts ***82*** and second contacts ***84*** lie within a substantially common plane. Also, the contacts ***82*** and ***84*** are disposed substantially transverse to each other.

[30] The connector ***80*** still further includes a body ***88***. The body ***88*** may be molded to carry the contacts ***82*** and ***84*** and encapsulate the capacitors ***86***.

[31] **FIG. 6** illustrates how the connector ***80*** may be employed to form one segment of a bladed style connector ***100***. In **FIG. 6**, it will be noted that the connector ***100*** includes a plurality of connector segments ***80***, ***110***, ***120***, ***130***, and ***140***, for example. Although five such segments are illustrated in **FIG. 6**, it is to be understood that the connector ***80*** may include any number of connector segments without departing from the present invention.

[32] The modularized structure of connector ***100*** permits a plurality of connector segments to be disposed with contact substantially parallel to each other. Further, the modularized structure of the connector ***100*** permits connector segments which provide capacitive coupling, such as segment ***80*** to be utilized along with connector segments, such as segment ***130***, which provide coupling but not capacitive coupling. Connector segment ***130*** is illustrated as an example of one connector segment which may be provided for providing direct and not AC coupled coupling. As will be noted in **FIG. 6**, the segment ***130*** includes a first male contact ***132*** and a second male contact ***134***. The contacts ***32*** and ***34*** are directly coupled together by a

conductor ***136***. Of course, as will be appreciated by those skilled in the art, the connector segment ***130*** may incorporate a plurality of the male contacts ***132*** and a corresponding plurality of male contacts ***134***.

[33] Also, a modularized structure of the connector ***100*** permits the contacts providing capacitive coupling to be distinguishable from the contacts which do not provide capacitive coupling. To that end, the contacts ***82*** and ***84*** may have a characteristic which distinguishes them from the contacts ***132*** and ***134***. This distinguishing characteristic may be, for example, cross-sectional shape or other physical distinguishing characteristic.

[34] As can be appreciated from the foregoing, the present invention provides a connector for distributing signals from one circuit device to another circuit device with capacitive coupling without requiring the circuit devices to incorporate surface mounted AC blocking capacitors and vias for accessing such capacitors. As a result, the deleterious effects of such vias are avoided without increasing the manufacturing costs of the circuit devices.

[35] Although the present invention has been described in considerable detail with reference to certain preferred embodiments, other embodiments are possible. Therefore, the spirit or scope of the appended claims should not be limited to the description of the embodiments contained therein. It is intended that the invention resides in the claims.